Electrochemical Method for Extraction of Oxygen from Air

Benefits

- Reduces power requirements compared with water electrolysis
- Builds on well-established solid polymer electrolyte fuel cell technology by using standard cathodic reactions already used in fuel cells
- Avoids possible complications through peroxide-reaction processes
- Offers a simpler, more compact system
- Targets a market poorly served by current oxygen-production technology

Applications

The new technology is primarily suited for producing 99 percent plus purity oxygen on-site in small hospitals, clinics, and long-term-care and acute-care nursing homes. Unlike larger facilities, which often operate their own central oxygen-supply systems, smaller facilities often receive their medical oxygen in high-pressure gas cylinders, which require delivery and increase costs. This invention will likely have secondary applications in a wide array of industrial and military situations.

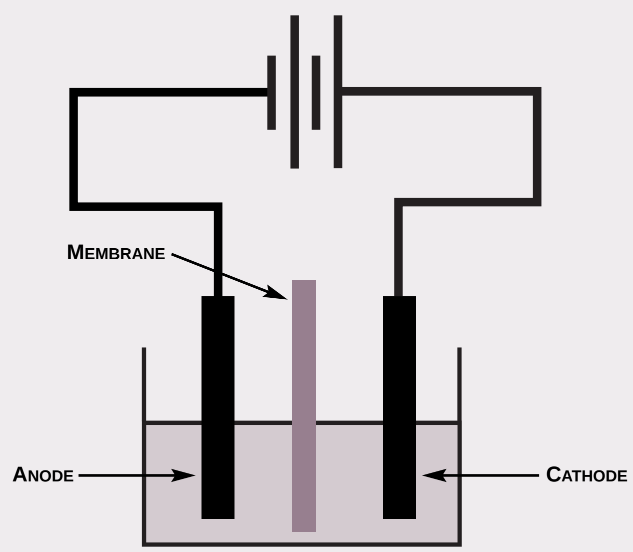
New method for extracting at least 99 percent pure oxygen reduces energy use

Water electrolysis is a common process for producing high-purity oxygen for medical and industrial use. However, this process has drawbacks, most notably the consumption of large quantities of energy and the co-production of hydrogen, which has safety and potential purity problems.

Because hydrogen is an unwanted by-product of water electrolysis, efforts have been made to try to minimize its impact. For example, the hydrogen has been used in fuel cells to reduce the electrolyzer's net energy requirement. The hydrogen is produced at the electrolyzer's cathode and then oxidized at the anode of the fuel cell. This process effectively recycles the hydrogen while helping to generate electricity.

A new technology, an electrochemical method for extracting pure oxygen from air, improves on previous technologies by eliminating the two hydrogen electrode reactions completely and combining the remaining oxygen electrode reactions in one unit. The result is an electrolyzer that produces oxygen at the anode and reduces oxygen at the cathode. In addition, the proprietary anodes and cathodes consume less power than traditional water electrolysis.

Electrochemical Method for Extraction of Oxygen



This new technology combines an oxygen evolution anode and a fuel cell oxygen reduction cathode to reduce energy consumption and eliminate the hydrogen by-product.

Project Description

Goal: Design, fabricate, and test a small electrochemical cell capable of extracting oxygen from air.

Prior research by experts in this field has concluded that extracting oxygen from air by electrochemical means can significantly reduce power requirements compared to the more conventional water electrolysis process. Some researchers used carbon-based cathodes to produce hydrogen peroxide by a two-electron process. The peroxide was then reduced within the cell using catalytic-decomposition meshes. This process, originally thought to be more efficient than the four-electron reduction-to-water step, has certain disadvantages. Carbon-based cathodes for oxygen reduction to peroxide are less developed, and while the catalytic-decomposition meshes may react with the hydrogen peroxide during the decomposition step, they may also trigger an oxygen-reduction process resulting in loss of activity or breakdown of the decomposition mesh.

In comparison, the new technology involving an oxygen-reduction cathode combined with an oxygen-evolving anode avoids the intermediate peroxide step. In addition, given that oxygen reduction is the standard cathodic reaction used in all fuel cells, the new system builds on technology—particularly solid-polymer fuel cell technology—that is already well accepted. The technology offers promise for a single, highly compact system capable of producing 99.9 percent medical-grade oxygen with significantly lower power requirements.

James Mulvihill and Associates is developing this new technology with the help of a grant funded by the Inventions and Innovation Program in the Department of Energy's Office of Industrial Technologies.

Progress and Milestones

- The developer has successfully negotiated partnering agreements both with a world leader in fuel-cell design and production and with the Faraday Centre, an international research center.
- Combined electrolytic oxygen cell preliminary tests have been completed.
- Ongoing experimentation is focused on determining actual power requirements, cell size, oxygen output, and other characteristics of the proposed technology.

Economics and Commercial Potential

There are two levels of medical-grade oxygen, 93 percent and 99 percent or higher purity. The 93 percent grade is produced from air by pressure-swing absorption, a molecular-sieve process. The proposed electrochemical method for extraction of oxygen from air, however, is expected to deliver 99.9 percent pure oxygen.

The primary target market for the proposed technology is smaller medical facilities, such as hospitals, clinics, and long-term-care and acute-care nursing homes with fewer than 100 beds. Market research estimates there were 6,600 hospitals and 16,700 nursing homes of all sizes in the United States in 1998, approximately half of which had less than 100 beds. Overall, it is estimated that these smaller facilities account for approximately 800,000 beds.

Smaller medical facilities presently rely on pressurized cylinders or pressure-swing absorption systems for their oxygen. However, both are expensive options that carry with them cost, safety, and efficiency disadvantages.

In contrast, the electrochemical method for extraction of oxygen from air is ideally suited for use in small facilities. Based on a consumption rate of one liter per minute per bed, the annual usage of medical-grade oxygen for these facilities is estimated to be 15,000 million cubic feet. At an average of $25 per 1,000 cubic feet for medical-grade cylinder oxygen, the market for medical-grade oxygen in facilities with fewer than 100 beds currently approaches $375 million. In a recent General Accounting Office (GAO) report on Medicare costs for home oxygen, costs for supplemental oxygen for patients at home amounted to approximately $1.9 billion in 1998.

The Inventions and Innovation Program works with inventors of energy-related technologies to establish technical performance and conduct early development. Ideas that have significant energy savings impact and market potential are chosen for financial assistance through a competitive solicitation process. Technical guidance and commercialization support are also extended to successful applicants.

Project Partners

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